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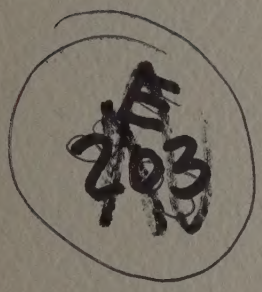

INSTRUCTION MANUAL

KEPCO®

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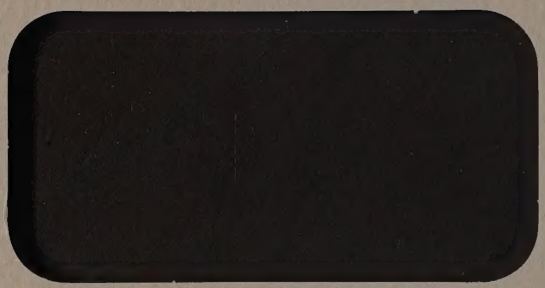

INSTRUCTION MANUAL

VOLTAGE REGULATED
POWER SUPPLY

MODEL SC 32-15A

SERIAL NO. . . . . .

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SECTION A SPECIFICATIONS AND CONTROLS

I. ELECTRICAL AND PHYSICAL SPECIFICATIONS:

.....DC OUTPUT VOLTAGE:
0-32 volts DC, continuously variable.

.....DC OUTPUT CURRENT:
0-15 amperes, continuous duty.

.....AC INPUT:
105-125 volts, 50-65 CPS.

.....REGULATION:
Line: Less than 0.01% for AC line fluctuations from 105-125 volts at any output voltage in the specified range.
Load: Less than 0.01% or 0.002 volts, whichever is greater, for 0 to 15 ampere step load change, at any output voltage in the specified range.

.....RIPPLE:
Less than 0.001 volt rms.

.....STABILITY:
Output variation is less than 0.01% or 0.002 volt, whichever is greater, over a period of 8 hours after unit has reached equilibrium. Approximately 3/4 of an hour is required for this unit to reach equilibrium from a "cold start". Drift during warm-up is less than 1%.

.....OUTPUT IMPEDANCE:
Less than 0.001 ohm from DC to 1 KC.
Less than 0.01 ohm from 1 KC to 100 KC.

.....RECOVERY TIME:
50 microseconds.

.....TEMPERATURE COEFFICIENT:
Output voltage changes less than 0.01% per °C.

.....AMBIENT OPERATING TEMPERATURE:
-20°C to 50°C maximum. Protective circuit turns off unit whenever over-temperature condition occurs. Interrupting input power resets unit.

.....STORAGE TEMPERATURE:
-40°C to +85°C.

.....*METERS (If specified):
Voltmeter: 0-50 volts, 2-1/2".
Ammeter: 0-15 amperes, 2-1/2".

.....DIMENSIONS:
Height 8-3/4", width 19", depth 14-3/8".

.....COLOR:
Kepco standard gray hammertone.

II. TERMINALS AND CONTROLS:

.....(On front panel):

....DC OUTPUT AND GROUND binding posts, clearly marked. Output terminals isolated from chassis; either positive or negative terminals may be grounded.
....VOLTAGE CONTROL continuously variable, one turn, for setting the desired output voltage.
....POWER ON-OFF toggle switch.

.....(On terminal board at rear of unit):

....DC OUTPUT AND GROUND terminals, clearly marked; either positive or negative output may be grounded.
....REMOTE ERROR SIGNAL terminals provide means of maintaining specified regulation directly at the load by compensating for voltage drops across load supply leads. (See Diagram and Procedure on Page C-1).

.....(On Control Unit, Tram 8, at rear of unit):

....MAXIMUM CURRENT ADJUST (MC): This adjustment is factory-set to automatically limit the output current to 120% of its maximum rating. If a current limiting effect is introduced by the voltage drop across the load supply leads, when using remote error sensing, the Maximum Current Adjust may be set clockwise to compensate for this effect. Care should be taken to see that this control is returned to its normal setting for standard operation.

III. PROTECTIVE FEATURES:

.....SHORT CIRCUIT PROTECTION:

When the load exceeds the maximum permissible output current by 20% the limiter amplifier automatically increases the impedance of the series pass transistors, so that their dissipation rating is never exceeded.

.....FUSE PROTECTION:

INPUT FUSE on front panel.
REFERENCE FUSE on rear apron of chassis.
POT FUSE on rear apron of chassis. This fuse has been designed into the circuit to protect the 10 turn voltage control in the event of any internal failure or accidental removing of jumper bars on the rear terminations when the unit is operating.

SECTION B.

THEORY OF OPERATION

This power supply is of a servo or closed loop design in which the pass elements are in series with the load. (See block diagram B-1).

The voltage drops in the closed loop system are automatically adjusted according to the comparison of a sample output voltage with the reference voltage in the CONTROL UNIT. The differential product of this comparison is amplified and fed back as the ERROR INPUT to control the voltage drop across the pass transistors. The ERROR INPUT to the PASS CIRCUITRY is a negative or degenerative feedback signal. Consequently, the voltage drop across the pass transistors is such as to oppose output voltage change.

CAPITALIZED TERMS ADOPTED FOR FOLLOWING OUTLINE AND DISCUSSION REFER TO DESIGNATIONS ON THE CIRCUIT SCHEMATICS IN THE REFERENCE INDEX.

.....1. POWER UNIT (Circuit Schematic Tile)

A. INPUT CONTROL CIRCUITRY - Controls power input from the line to the DC SOURCES.

B. DC SOURCES - Provide main and auxiliary rectified power for all DC circuitry.

C. PASS CIRCUITRY - In the MAIN DC path to the output. All current drawn by the load goes through the pass elements, hence the name.

.....II. CONTROL UNIT (Circuit Schematic Tile)

A. REFERENCE VOLTAGE CIRCUITRY - Maintains a stable voltage standard for the comparison circuitry.

B. THE COMPARISON AMPLIFIER - Functions as the "error sensing" and cascade amplification circuit.

.....III. COMPARISON BRIDGE -

Consists of elements in both the POWER UNIT and CONTROL UNIT in a circuit configuration which effects a comparison between an output voltage sample and a stable reference voltage.

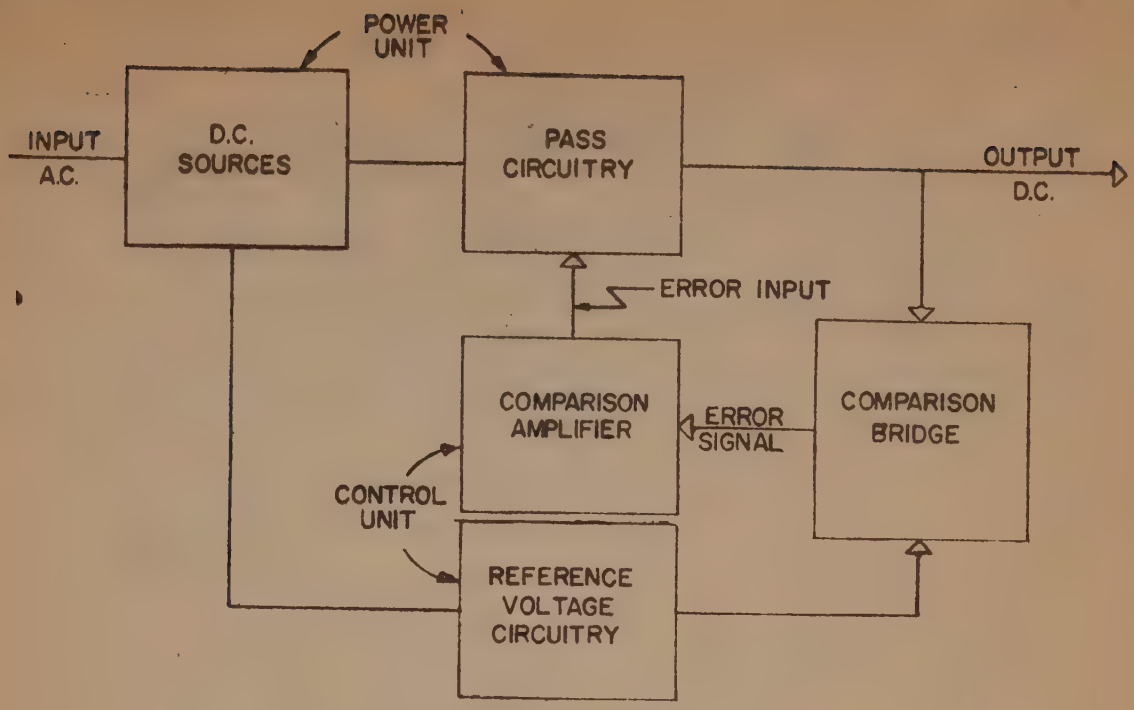


DIAGRAM B-1

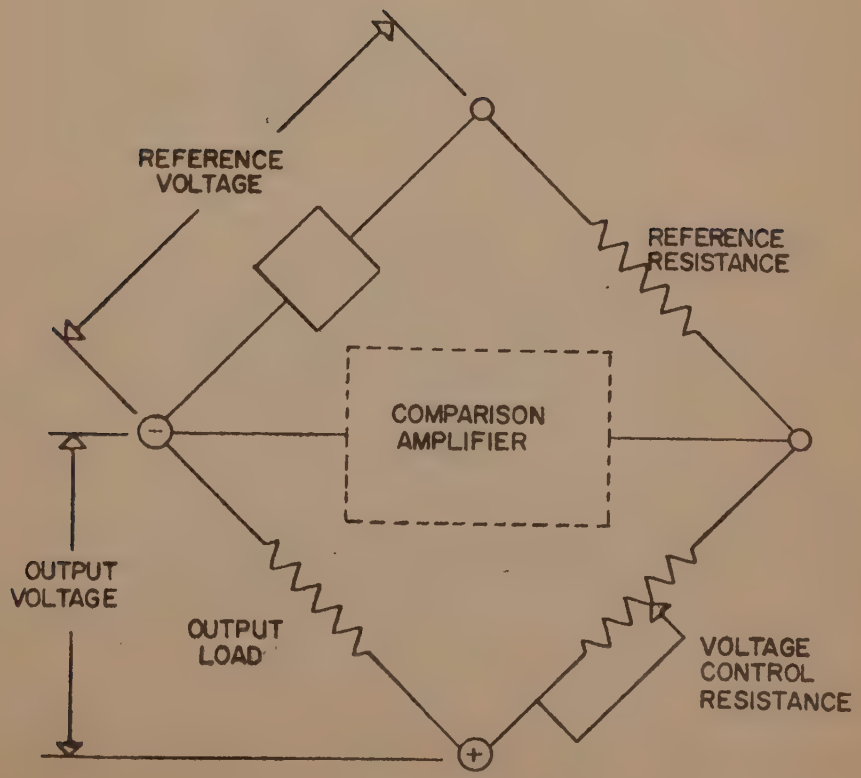


DIAGRAM B-2

NOTE:

The following discussion describes the elements of the foregoing outline in greater detail. As before, capitalized terms refer to designations on the schematic diagrams. Some of this discussion is of a general nature and may not apply in every detail to this specific model. Variations in the basic outline occur primarily in connection with the PASS CIRCUITRY INPUT, CONTROL CIRCUITRY or the REFERENCE VOLTAGE CIRCUITRY and reflect design considerations relevant to the particular output requirements of the model. It should not be assumed that a set of circuit schematics is incomplete because it does not include all of the reference nomenclature used in this discussion.

I. POWER UNIT

A. INPUT CONTROL CIRCUIT:

(1) With the input switch closed, a forward bias on one semiconductor diode in the ENERGIZING CIRCUIT will draw a charging current for the capacitor which energizes the INPUT RELAY coil closing the input to the DC SOURCES transformers. As soon as the INPUT RELAY is closed, the DC in the input control circuit circulates through the thermal relay and input relay coil, bypassing the charged capacitor and holding the relay closed.

(2) If the pass element containing the thermostat control becomes overheated, the thermal switch opens the DC path to the INPUT RELAY de-energizing the relay coil and cutting off the input to the DC SOURCES.

NOTE:

The AC line power must be interrupted in order to reset the input relay after the thermal switch has opened the input to the DC SOURCES. Once the capacitor in the ENERGIZING CIRCUIT is charged, it cannot hold the relay when the thermal switch opens. This action tends to prevent damage to the pass elements from overheating in case the transistor associated with the thermostat dissipates heat faster than the other pass elements.

(3) When the input relay is opened by the action of the thermal switch or by pulling the line cord, the DISCHARGE RESISTOR effectively shorts the MAIN FILTER CAPACITOR preventing overvoltage surges.

NOTE:

For Models SC 18-4, SC 36-2 and SC 3672-1 substitute the following paragraph for section I-A.

These models employ a slightly different turn-on circuit - refer to schematic diagram.

....I. POWER INPUT

A. INPUT CONTROL CIRCUIT:

(1) INPUT RELAY automatically interrupts the power input to the DC SOURCES whenever the thermostat control detects overheating in the PASS CIRCUITRY. When it is thrown in response to an over-temperature condition, it provides a discharge path for the MAIN FILTER capacitor.

(2) OVERVOLTAGE RELAY provides a discharge path for the MAIN FILTER capacitor whenever the line input is interrupted.

(3) DISCHARGE RESISTOR - When the input to the DC SOURCES is opened by interrupted line power or the action of the thermostat control, the DISCHARGE RESISTOR effectively shorts the MAIN FILTER capacitor. This prevents overvoltage surges.

B. DC SOURCES:

(1) RETURN SUPPLY (full wave rectified and filtered) - provides a return path for leakage current (I_{CO}) from the pass transistors.

It is also a bleed path which provides a minimum operating current for the emitters of the pass transistors, enabling them to continue to remain operative or "sensitive" to the ERROR INPUT when the load current becomes zero or vanishingly small.

(2) MAIN SUPPLY (full wave rectified and filtered) - provides MAIN DC for the output, subject to the regulatory action of the PASS CIRCUITRY. The MAIN DC path includes the pass elements and the load in series.

(3) I_{CO} SUPPLY (full wave rectified) - Provides a supply of current to prevent spurious biasing of the pass transistors by collector leakage current (I_{CO}). I_{CO} generated as a function of temperature and flowing oppositely to the emitter base current tends to alter the ERROR INPUT unless this compensating supply provides bias stabilization.

(4) COLLECTOR SUPPLIES (negative half-cycle rectified) - provide proper collector bias for the PRE-DRIVERS.

C. PASS CIRCUITRY:

The power transistors which function as pass elements may be regarded as electronic variable resistors (or variable conductors) controlled or "varied" by an amplified ERROR INPUT. The amount of current "passed" by these transistors is a function of the magnitude of the forward conducting emitter-base bias. Since the ERROR INPUT is applied to the base terminal, a negative input will aid the forward conducting bias of a PNP transistor while a positive input will reduce the forward conducting bias. In response to the polarity and magnitude of the ERROR INPUT, the pass transistors control the current and voltage distribution in the MAIN DC loop and effect a constant output voltage.

Two main classifications of pass transistors may be indicated on the schematic acoording to the way in which they are driven:

(1) DRIVEN PASS - "driven" by the ERROR INPUT from the CONTROL UNIT. A DRIVER and a PRE-DRIVER may be connected in cascade with the DRIVEN PASS. These amplification stages increase the response and sensitivity of the system to output voltage changes. The DRIVEN PASS may be a single series pass transistor

or a series pass group of transistors connected in parallel for increased current capacity.

(2) SLAVE PASS - found in transistorized units requiring more than one series pass group in the MAIN DC path. These pass transistors "slavishly" follow the response of the DRIVEN PASS to the ERROR INPUT. The SLAVE PASSES are driven through a SLAVE VOLTAGE DIVIDER which effects an approximately equal voltage division among the series pass groups in models where the voltage range requires more than one group of series pass elements. The SLAVE PASSES may or may not have preliminary amplification stages in cascade.

When series pass groups contain transistors connected in parallel, an EQUALIZING RESISTOR is associated with each transistor. These EQUALIZING RESISTORS, tied to each emitter, provide a means of compensation for intrinsic differences among transistors within a pass group.

The expression "drop voltage" is sometimes used to describe the amount of voltage drop required of the pass elements to bring the COMPARISON BRIDGE into balance. This is the difference between the input and the desired output. True balance or stability is inherently impossible in a servo system, but the unbalance may be reduced to as small a magnitude as desired in a dynamically corrective system.

.....II. CONTROL UNIT

A. REFERENCE VOLTAGE CIRCUITRY:

The function of the REFERENCE VOLTAGE CIRCUITRY is to maintain a precise, stable voltage for the COMPARISON BRIDGE. This is normally achieved according to the model CONTROL UNIT with either of two basic design approaches:

(1) A CASCADE ZENER REFERENCE, consisting of Zener diodes of succesively decreasing values in cascaded stages each of which produce an increasingly regulated reference voltage. In practice, usually only two stages are used so that in effect the first Zener diode is a regulator for a voltage reference diode.

(2) Balanced amplifier regulation - Any disparity between the bases of the transistors in the set of 1st BALANCED AMPLIFIERS is coupled to the set of 2nd BALANCED AMPLIFIERS. The 2nd BALANCED AMPLIFIERS couple this amplified "error signal" to a REFERENCE DRIVER and a REFERENCE PASS which regulate the current through a REFERENCE DIODE in a manner analogous to the action of the PASS CIRCUITRY in the POWER UNIT.

B. COMPARISON AMPLIFIER CIRCUITRY:

(1) The COMPARISON AMPLIFIER consists of a series of cascaded transistor amplifiers which boost the "error input" to a sufficient level to drive the PASS CIRCUITRY in the POWER UNIT.

(2) The COMPARISON AMPLIFIER is connected across the COMPARISON BRIDGE from the junction of the VOLTAGE CONTROL and the REFERENCE RESISTANCE to the junction of the Zener reference diode and the negative output terminal. (See Diagram B-2). This arrangement is similar to that of the null galvanometer across a Wheatstone bridge. The unbalance in the COMPARISON BRIDGE is detected and amplified by the COMPARISON AMPLIFIER CIRCUITRY beginning a chain of circuit responses which produce an ERROR INPUT signal of proper phase and magnitude to effect corrective action by the pass circuitry.

.....III. Comparison Bridge:

(1) This bridge circuit implements the comparison between the OUTPUT VOLTAGE and the REFERENCE VOLTAGE. The signal produced by the comparison drives the COMPARISON AMPLIFIER CIRCUITRY.

(2) The Comparison Bridge is represented schematically in Diagram B-2.

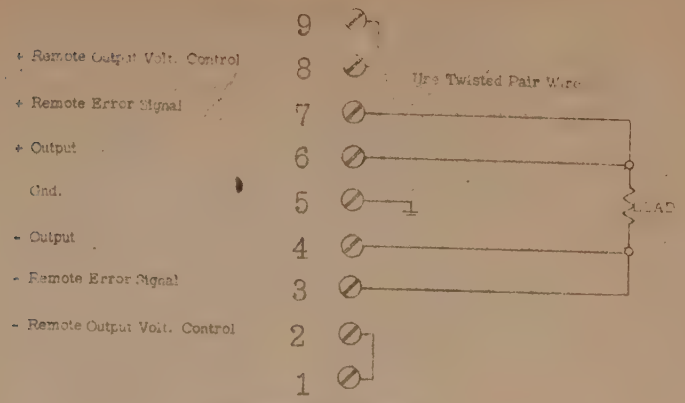
(3) Balance occurs in the Comparison Bridge when the following ratios are equal:

$$\frac{\text{Output Voltage}}{\text{Voltage Control Resistance}} = \frac{\text{Reference Voltage}}{\text{Reference Resistance}}$$

(4) When the Comparison Bridge is unbalanced by a decreasing output voltage drop across the load, it gives rise to a negative bias at the base of the COMPARISON FOLLOWER in the COMPARISON AMPLIFIER CIRCUITRY. This signal, amplified, acting as the ERROR INPUT negatively biases the base of the DRIVEN PASS, aiding its forward conducting bias and increasing the output voltage.

(5) A bridge unbalance caused by an increasing output voltage produces, of course, a chain of oppositely biased circuit responses which reduce the voltage across the load.

CONVERTING TO REMOTE ERROR SENSING



PROCEDURE:

1. With AC input disconnected, remove jumper between POSITIVE OUTPUT and POSITIVE REMOTE ERROR SIGNAL (terminals 6 and 7) between NEGATIVE OUTPUT and NEGATIVE REMOTE ERROR SIGNAL (terminals 4 and 3) on rear terminal strip.

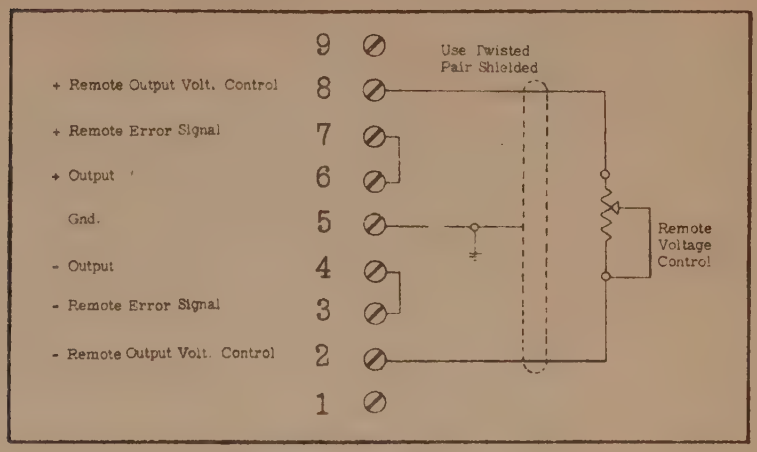
2. Using twisted pair wire, connect sensing leads from POSITIVE REMOTE ERROR SIGNAL (terminal 7) and from NEGATIVE REMOTE SIGNAL (terminal 3) to the load, observing polarities.

3. Using twisted pair wire, connect load supply leads from POSITIVE OUTPUT (terminal 6) and NEGATIVE OUTPUT (terminal 4) to the load.

NOTE: In operations requiring remote error sensing, voltage drops across the load supply leads will change the effective setting of the maximum current adjustment and possibly worsen regulation. By setting the MAXIMUM CURRENT ADJUST on the CONTROL UNIT it is possible to compensate for this effect for up to a maximum drop of 1/2 volt across the negative load supply lead. The 1/2 volt limit is imposed by the fact that this drop reduces the maximum forward conducting bias on the series pass transistors. The input base bias to the pass transistor is limited by the factory setting of the MAXIMUM CURRENT ADJUST. Consequently to avoid a deterioration in the ability of the pass transistors to follow the ERROR SIGNAL feedback and correct the output voltage, the following steps should be taken:

1. Turn CURRENT LIMIT ADJUST (if provided) to maximum clockwise position.
2. Load the power supply with the remote resistance necessary to draw slightly more than 120% of the maximum rated supply current at the indicated supply output voltage.
3. Turn MAXIMUM CURRENT ADJUST clockwise until output current reaches 120% of maximum rating.

CONVERTING TO REMOTE OUTPUT VOLTAGE CONTROL



TERMINAL BOARD

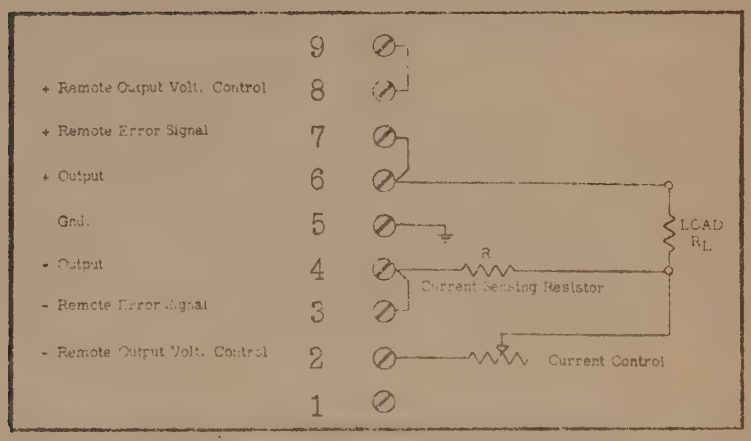
PROCEDURE:

1. The REMOTE VOLTAGE CONTROL resistance, fixed or variable, should be equal to the product of the desired output voltage and the ohms per volt ratio specified for this model. (See discussion on REMOTE OUTPUT VOLTAGE CONTROL terminals in Section A).

2. With AC power disconnected, remove jumper between POSITIVE REMOTE OUTPUT VOLTAGE CONTROL (terminal 8) and terminal 9, and jumper between NEGATIVE REMOTE OUTPUT VOLTAGE CONTROL (terminal 2) and terminal 1.

3. Connect shielded twisted pair wire leads from POSITIVE REMOTE OUTPUT VOLTAGE CONTROL (terminal 8), and from NEGATIVE REMOTE OUTPUT VOLTAGE CONTROL (terminal 2) to REMOTE VOLTAGE CONTROL resistance. REMOTE VOLTAGE CONTROL, if variable, should be connected so that clockwise rotation increases resistance.

CONVERTING TO CURRENT REGULATED OPERATION



TERMINAL BOARD

PROCEDURE:

1. Remove jumper between NEGATIVE REMOTE OUTPUT VOLTAGE CONTROL (terminal 2) and terminal 1.

2. Connect a CURRENT CONTROL resistor from the NEGATIVE REMOTE OUTPUT VOLTAGE CONTROL (terminal 2) to the load as shown in the above diagram. The CURRENT CONTROL resistance should be numerically equal to (in ohms) or greater than the ohms/volt ratio specified for this unit in the discussion on REMOTE OUTPUT VOLTAGE CONTROL terminals in Section A. (e.g. for a 330 ohms/volt model use a 500 ohm pot.).

3. Choose a CURRENT SENSING resistance sufficient to produce a 1 volt drop at maximum desired output current. Connect this CURRENT SENSING resistor in series with the external load R_L and the NEGATIVE OUTPUT (terminal 4).

   Current Sensing Res. = 1 / max. output amps. desired

SECTION 4
MAINTENANCE AND REPAIRS

4-1 GENERAL INFORMATION. -

The performance of this Power Supply will in a sense be dependent on the collective performance of all of its components. Kepco chooses and tests these components to provide long life and trouble-free operation of the unit.

However, if component failure should occur, it is recommended that troubleshooting be handled by personnel familiar with transistor circuitry, preferably with experience in feedback regulator design. The essential regulating circuitry is a closed-loop DC servo system. The same circuit sensitivity which enables a high degree of regulation to be obtained also increases the susceptibility of the circuit to interrelated functional disorders if the equipment is improperly serviced.

....REFERENCE MATERIAL. -

The Instruction Manual furnished with the Power Supply is identified with the serial number of the unit, assuring that the information it contains is correct and current for the unit to which it applies. The following reference material is provided in the Manual to aid in troubleshooting and repairs:

1. Large schematic diagrams showing essential voltage measurements and component values.

2. Parts location photos or drawings.

3. Parts lists identifying all replacement parts with description and specifications, and the name and manufacturer's part number of at least one replacement source for each item.

....FACTORY REPAIRS. -

If it becomes necessary or desirable to return the equipment to KEPCO for servicing, it should not be shipped to the factory without the sender having prior authorization and shipping instructions. The inclusion of detailed information with the unit, or in correspondence preceding its return to the factory will greatly expedite completion of repairs and return of the equipment to the sender.

In any correspondence with the factory about this Power Supply, the model and serial numbers should always be included.

4-2 MAINTENANCE. -

Under normal operating conditions, only a minimum of maintenance may be required.

1. Fan Assemblies. - If the unit is equipped with muffin-type fan assemblies (black impeller, motor enclosed in hub), this type is permanently lubricated by the manufacturer and does not require relubrication. The open frame type of motor may be lubricated lightly every six months.

2. Brushes. - In units that contain a variable transformer, the brush assembly should not as a rule ever require maintenance or replacement. If it is desired to clean the commutator track, use only a soft cloth moistened lightly with an electrical cleaner (not a solvent). Never use any type of abrasive material on the track.

3. Vacuum Tube Replacement. - Vacuum tubes may be replaced as required when they become defective, or at arbitrary intervals of either life or use. Unless specifically indicated, tubes may be replaced individually and need not be replaced in sets or groups.

4. Performance Tests. - If the unit is to be tested and measured to determine its performance with respect to Regulation, Ripple, etc., the section in the Manual on Regulation Measurements should be read, and the recommended procedures contained therein, or their equivalent, should be followed to aid in obtaining accurate test measurements.

....PRELIMINARY TROUBLESHOOTING CHECKS. - Before proceeding with any extensive electrical troubleshooting, it is advisable to carefully check the Supply for any operational or mechanical disorders.

1. Check for broken, loose, or shorted terminals, wires, and connections; loose connectors, open or loose fuses, tripped circuit breakers, etc. Check all internal as well as external fuses.

2. If the malfunction relates to an overtemperature condition, check to see that the fans work properly and that the openings weren't blocked during operation. On units with overtemperature protection be sure to allow enough time for the thermostat switch to cool and to restore to normal position.

3. Check all operational functions and controls for proper settings. For example, on units with automatic current limiting, a low current setting can, under certain conditions, have the effect of limiting the output voltage, which may appear to be a malfunction. Check to determine whether any internal adjustments may have been reset for any reason, and left at a setting that is incorrect.

4-3 NOTES ON TRANSISTOR SERVICING TECHNIQUES.

....MECHANICAL.

1. A transistor should not be disconnected from, or connected to its circuit while voltage is still present in the circuit.

2. When a soldering iron must be used to remove or install a transistor, or a diode, the heat of the iron while it is being applied to the terminals will almost certainly damage the component unless precautions are taken to prevent it:

   a. When soldering, always apply a temporary "heat sink" to the leads between the iron and the semiconductor to drain off the heat travelling up the lead.

      Note: Pliers are often used for this purpose - be sure they are effective; e.g., flat blade "duck-bills" are good, narrow blade or "toothed" long-nose pliers may be poor.

   b. Solder quickly, so as to limit the application of heat to the briefest possible duration. In this respect use a good iron with proper and sufficient heat for the connection. An iron of too low heat tends to require longer application.

3. When removing or installing a transistor or a diode which has its case connected to one of its elements, be sure to preserve the arrangement of any insulating materials, such as mica washers or bushings.

4. When installing plug-in transistors which have flexible leads, be sure to align the leads and socket pins properly; especially in the "universal" sockets which were designed to accommodate more than one lead pattern.

....ELECTRICAL.

1. Transistor Testers. - Transistor checking instruments, either commercial types or those of local design, may be used. These are usually effective and practical, but not in every case, depending on many circumstances including the accessibility of the unit under test, and the range of the instrument.

2. In-Circuit Analysis. - In some cases the condition of a transistor may be determined by observing certain of its electrical characteristics while it is operating in the circuit. These may range from voltage readings to AC analysis with an oscilloscope.

3. Ohmmeter Check. - Transistor failures of a more complete nature such as shorted or open junctions may be easily detected by test with an ohmmeter. However, some precautions are necessary:

   a. Use the low ohms scale only (Rx1), and then only if the source voltage of the meter (battery) is not more than 2 volts. The use of a higher range or one with high battery voltage may give erroneous indications and might even damage a transistor.

   b. The "common: or black terminal on most ohmmeter instruments is the Positive terminal of the ohmmeter battery, not negative as is commonly believed. When checking semiconductors with an ohmmeter it is usually necessary to know the polarity of this voltage in order to interpret the readings obtained. Some manufacturers of ohmmeters are now indicating this polarity on their meters.

   c. An ohmmeter test between any two terminals of a transistor indicates by the needle deflection whether it is conducting ohmmeter current between those two terminals; and the amount of deflection is related to the amount of this current and to the voltage drop developed across the junction. The actual reading in ohms is not as significant as are other conclusions from the readings. With the polarity of the meter applied as a forward bias to either the base-emitter or base-collector junction, forward current should flow with the needle deflecting on the order of 5-50 ohms; with the polarity reversed in either case, only leakage current flows with little or no perceptible deflection. In both cases the apparent ratio between readings of opposite applied polarity should be on the order of at least 100 to 1. A reading between emitter and collector should be high in both directions.

   d. When an ohmmeter is used to test a transistor that is still in the circuit, the parallel effects of other components in the circuit should be taken into consideration.

4. Substitution. - The above procedures are very often used to localize a trouble down to a circuit area or to one component with final proof dependent on substituting a known good component. It is possible for one bad transistor in a circuit to "pull" another one with it. When a transistor is found to be defective, it should not be replaced before all others have been checked, including those which would appear to be not directly associated in the circuit with the defective one.

....DIODES.

1. Most of the preceding material on transistors is applicable to diodes, except that diodes are two terminal devices consisting of a single junction. The ratio of "front to back" readings on an ohmmeter should similarly be on the order of 100 to 1.

2. When replacing diodes, be sure to observe the proper polarity:

   a. The "triangle" of a diode symbol represents the anode and "points" in the direction of forward conduction under conditions of applied forward bias.

   b. Diodes are marked with their polarity in terms of their output and the cathode is marked positive (+).

....ZENER DIODES.

1. Zener diodes may be checked with an ohmmeter provided they are of a single junction type. Double anode types have a common cathode which is not brought out to a terminal. Thus, whichever polarity of the ohmmeter is applied to the two anode terminals, it will read a high resistance reverse bias in both directions. A short however, can be detected. Manufacturers are not yet consistent in their marking of polarity on Zeners; before disconnecting a Zener, be sure to note its markings with respect to the terminals to which it is connected.

2. A positive test of a Zener diode is to measure the voltage across it while it is in operation. If instrumentation is available, the voltage regulation across its terminals should be measured and compared to its ratings.

4-4 POWER SUPPLY MEASUREMENTS. -

....DEFINITIONS -

Line Regulation. - Stated in percentage of the output voltage, Line Regulation specifies the maximum amount that the output voltage will change as the result of a specified change in line voltage, with the load maintained at a constant value.

Load Regulation. - Stated in percentage of the output voltage (or in actual value) specifies the maximum amount that the output voltage will change as the result of a specified change in output load current, with the line voltage maintained at a constant value.

MEASURING REGULATION. -

Load Regulation and other performance characteristics can be measured at any point in a system. However the results obtained will apply only to the specific point at which they are measured, and may differ from what is specified for the output of the Supply. If it is desired to measure or to verify the performance of the Supply itself, the measurements should be made at the terminals on the Supply, using instrumentation and procedures that are capable of measuring with the desired accuracy.

As an example, consider a Kepco Model SC 32-5, 32 volt/5 ampere Supply which has 0.01% regulation. At 32 volts, the output voltage at the terminals will not change more than 3.2 millivolts (0.0032 v) for a change from no-load to full-load. If the load were to be connected by only 12 inches of #12 gage wire in each lead, at full-load the total drop across the resistance in these wires would amount to 16 millivolts, equivalent to 5 times the voltage change within regulation. The regulation measured at the load would be 0.05% while at the terminals it would measure 0.01%.

Instrumentation. -

1. Line Voltage. - By definition, load regulation is specified, and measured with a condition of constant line voltage. A constant voltage transformer or other source of constant AC is required. If the AC source is also adjustable it can be used to vary or step the line voltage input for measuring Line Regulation.

2. Load. - An accurate full-load is required, preferably one that can be conveniently applied, or stepped on and off by some switching means.

3. Measurement. - Any instrument may be used that is capable of measuring both the absolute value of the output voltage, and the small magnitude of change in the output voltage occurring as the line or load changes are applied.

a. A differential voltmeter may be used; or a power supply analyzer such as the Kepco Regulation Analyzer Model 901C which gives measurements directly in percentage.

b. A DC coupled oscilloscope may be used, if a suitable auxiliary DC voltage is available to buck-out the voltage under test so that only the net change can be measured. The buck-out voltage must be at least equal in magnitude to, and have a greater order of regulation than the voltage under test.

Procedure. -

1. On Supplies that have more than one set of output terminals (most Kepco Supplies have terminals on the front and the rear) measurement can be made at either set, except on those Supplies where the regulation is specified for one particular set of terminals. In any case, both the load and the measuring instrument should be connected to the same terminals.

2. To avoid terminal losses giving erroneous measurements, on each output terminal connect the load to one end and the instrument to the other end of a short length of #14 bus wire looped around the terminal, as shown in Fig. 4-1.

3. The Supply should not be set up for Remote Error sensing where this facility is provided. Error Sensing jumpers to the output terminals, where employed, should be securely in place.

....RIPPLE MEASUREMENT.

Any AC ripple component present in the DC output of a properly functioning Power Supply will be small in magnitude, on the order of millivolts. It is usually stated in the specifications for the Supply either in millivolts RMS or in percentage (in RMS) of the output voltage. Because of its small magnitude, a sensitive instrument must be used to measure the ripple, and care must be exercised in order to obtain accurate readings.

1. Be certain that the input to the measuring instrument contains a blocking capacitor to isolate the DC voltage from the ripple component, and that the DC voltage rating of the capacitor is sufficiently high for the DC output voltage that will be applied.

2. Some rectifier types of AC meters do not contain a DC blocking capacitor, and DC current will pass through the rectifier to the meter movement. In such cases, or where the internal capacitor does not have a high enough DC rating, a 0.1 μf capacitor (with sufficiently high DCWV) connected in series with the high side of the input will insure isolation of the DC from the ripple.

3. Interconnecting leads between the Power Supply and the instrument should be short and preferably shielded to prevent stray AC pickup. When using a measuring instrument that is connected to the same power line, be certain to have good connections in the interconnecting leads to avoid the introduction of a ground loop.

CONNECTIONS FOR REGULATION MEASUREMENT

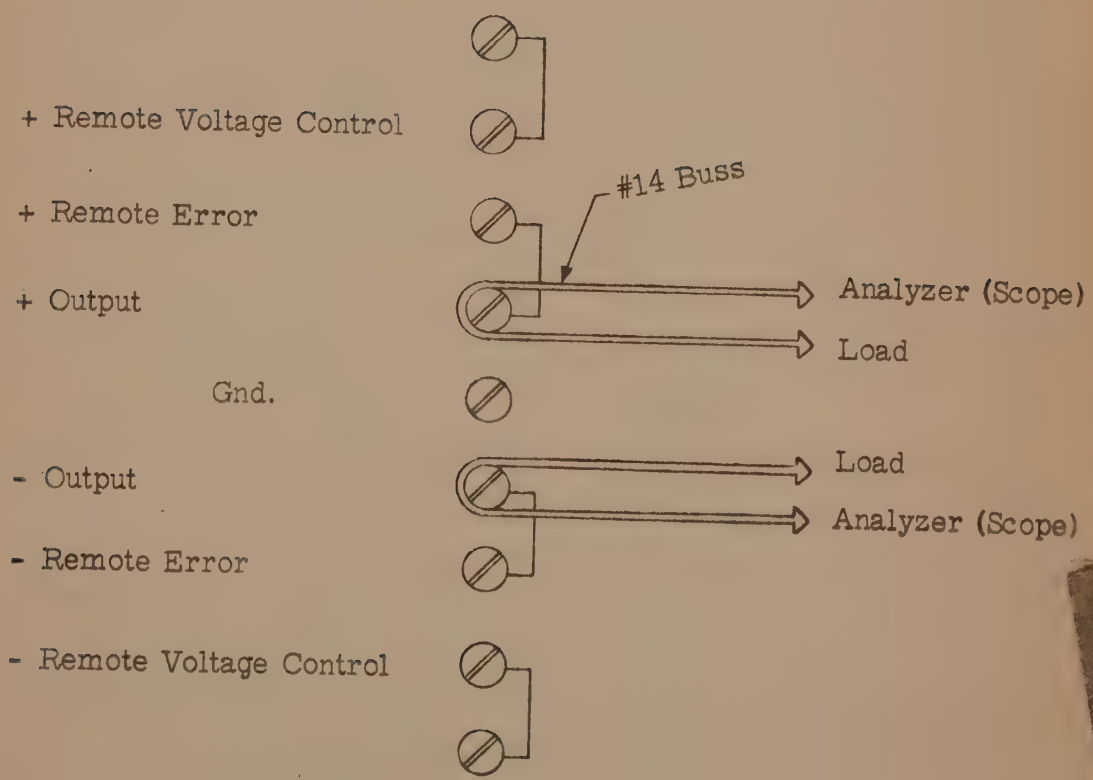


Fig. 4-1 Connections for Measuring Regulation

kepco®

REPLACEMENT PARTS LIST

POWER SUPPLY MODEL SC 32-15A Code 2-2461

SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
B201	1	Motor	Brevel M14-1C3-1128B	148-0017
C101	1	Capacitor,Mylar 1 µf, 200 V	Hopkins Engrg. 1P2MK	117-0207
C201-206	6	Capacitor,Electrol.,Can Type 2400 µf, 65 V	Industrial Cond. 1B1002RRB	117-0192
C207-209	3	Capacitor,Electrol.,Can Type 4200 µf, 50 V	Industrial Cond. 1B913RRB	117-0159
C210	1	Capacitor,Ceramic 0.1 µf, 500 V	Sprague 41C92	117-0087
C211-214	4	Capacitor,Mylar 0.5 µf, 200 V	Hopkins Engrg. P52MK	117-0123
C301,302	2	Capacitor,Electrol.,Pigtail 500 µf, 12 V	Industrial Cond. 1B1065	117-0156
C303	1	Capacitor,Electrol.,Pigtail 350 µf, 50 V	Industrial Cond. 1B844	117-0114
C304	1	Capacitor,Electrol.,Pigtail 100 µf, 150 V	Industrial Cond. 10B916RM	117-0140
C305,306	2	Capacitor,Mylar 0.4 µf, 200 V, 10%	Hopkins Engrg. P42MK	117-0128
C401,403	2	Capacitor,Electrol.,Pigtail 10 µf, 150 V	Industrial Cond. 10B912RM	117-0147
C402	1	Capacitor,Mylar 0.22 µf, 200 V	Good-All 620S22402W	117-0107
CR201	1	Silicon Rectifier,Stack Type	Trans-Sil 4T1015B1S1	124-0074
CR301-306	6	Germanium Rectifier,Pigtail	General Electric 1N91	122-0007
CR307-310	4	Silicon Rectifier,Pigtail	Automatic Mfg. PT-5	124-0028
CR401,402	2	Silicon Rectifier,Pigtail	Automatic Mfg. PT-5	124-0028
F101	1	Fuse,Instantaneous 15 A, 250 V	Bussman ABC-15	141-0010
F201	1	Fuse,Instantaneous ½ A, 250 V	Bussman AGC-½	141-0005
F202	1	Fuse,Instantaneous 1½ A, 250 V	Bussman AGC-1½	141-0009

REPLACEMENT PARTS MAY BE ORDERED FROM KEPCO, INC. ORDERS SHOULD INCLUDE KEPCO PART NUMBER AND DESCRIPTION.

PLEASE NOTE: THE MANUFACTURER'S NAME AND PART NUMBER LISTED FOR EACH ITEM ON REPLACEMENT PARTS LISTS REPRESENTS AT LEAST ONE SOURCE FOR SATISFACTORY MATERIAL AND IS USED SOLELY FOR THE CONVENIENCE OF KEPCO EQUIPMENT OWNERS IN ORDERING REPLACEMENT PARTS. WHILE WE RESERVE THE RIGHT TO USE EQUIVALENT ITEMS FROM ALTERNATE SOURCES

SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS NAME & PART NO. (See Note)	KEPCO PART NO.
*M101	1	Meter 0-15 A DC	General Electric 8DW91A230BX2	135-0141
*M102	1	Meter 0-50 V DC	General Electric 8DW91V201AR2	135-0138
PL101	1	Pilot Light,Neon	General Electric NE-51	153-0024
Q301	1	Transistor,PNP	Tung Sol	**119-0022
R101	1	Resistor,Variable,Multiturn 10 K ohm, 10 Turn, 1.25 W	Beckman Instrument AR10KL.25	115-0420
R201	1	Resistor,Wire Wound 0.033 ohm, 15 W	Kepco,Inc.	115-0797
R202	1	Resistor,Fixed,Power,Strip 250 ohm, 40 W, 5%	Ward Leonard 40S250	115-0184
R203	1	Resistor,Fixed,Power,Strip 100 ohm, 40 W, 5%	Ward Leonard 40S100	115-0594
R204,206	2	Resistor,Fixed,Power,Strip 500 ohm, 20 W, 5%	Ward Leonard 20S500	115-0551
R205	1	Resistor,Fixed,Power,Strip 10 ohm, 20 W, 5%	Ward Leonard 20S10	115-0727
R207,208	2	Resistor,Fixed,Molded 47 ohm, ½ W, 10%	Allen Bradley EB4701	115-0718
R301	1	Resistor,Fixed,Power,Axial 30 ohm, 3 W, 5%	Ward Leonard 3X30	115-0773
R302	1	Resistor,Fixed,Molded 470 ohm, ½ W, 10%	Allen Bradley EB4711	115-0608
R303	1	Resistor,Fixed,Molded 2 K ohm, 2 W, 5%	Allen Bradley HB2025	115-0074
R304	1	Resistor,Fixed,Molded 3.3 K ohm, ½ W, 5%	Allen Bradley EB3325	115-0452
R305	1	Resistor,Fixed,Molded 47 ohm, ½ W, 10%	Allen Bradley EB4701	115-0718
R306	1	Resistor,Fixed,Molded 430 ohm, ½ W, 5%	Allen Bradley EB4315	115-0581
R401	1	Resistor,Fixed,Molded 82 K ohm, ½ W, 10%	Allen Bradley EB8231	115-0776

* Metered Models Only.

** See Field Replacement Page.

REPLACEMENT PARTS MAY BE ORDERED FROM KEPCO INC. ORDER BY INCLUDING PART NUMBER AND DESCRIPTION.

PLEASE NOTE: THE MANUFACTURER'S NAME AND PART NUMBER IS AT LEAST ONE SOURCE FOR THAT ITEM AND IS LISTED SOLELY FOR ING REPLACEMENT PARTS LOCALLY WE RESERVE THE RIGHT TO USE EACH ITEM ON REPLACEMENT PARTS LISTS REPRESENTS ONVEN EQUIPMENT OWNERS IN OBTAIN ENT ITEMS FROM ALTERNATE SOURCES. KEPCO, INC.

POWER SUPPLY MODEL SC 32-15A Code 2-2461

SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
RL201	1	Relay,4PDT 115 V AC	Ohmite DOX-53T	140-0038
RL202	1	Relay,SPDT 115 V AC	Potter & Brumfield MP-5A	140-0037
S101	1	Switch,Toggle,SPST 15 A, 125 V	Carling AA252-63XKEP2	127-0107
T101	1	Transformer,Variable	Superior Electric Q116U	175-0331
T201	1	Transformer,Power	Kepco Magnetics 100-1143	100-1143
T202	1	Transformer,Power	Kepco Magnetics 100-1142	100-1142
T203	1	Transformer,Reference	Kepco Magnetics 100-1039	100-1039
TRANSISTOR ASSEMBLY:				
A901-A924 A926-A930	29	Pass Assembly Includes the following:	Kepco,Inc.	110-0102
	lea.	Transistor,PNP	Delco	**119-0016
	lea.	Resistor,Fixed,Power,Axial 1.5 ohm, 3 W, 5%	Ward Leonard 3X1.5	115-0517
A925	1	Pass Assembly Includes the following:	Kepco,Inc.	110-0103
	lea.	Transistor,PNP	Delco	**119-0016
	lea.	Resistor,Fixed,Power,Axial 1.5 ohm, 3 W, 5%	Ward Leonard 3X1.5	115-0517
	lea.	Thermostat,Switch N.C. 73°C	Chatham Controls DRSCORP73C	127-0093
A931	1	Driver Assembly Includes the following:	Kepco,Inc.	110-0105
	lea.	Transistor,PNP	Delco	**119-0016

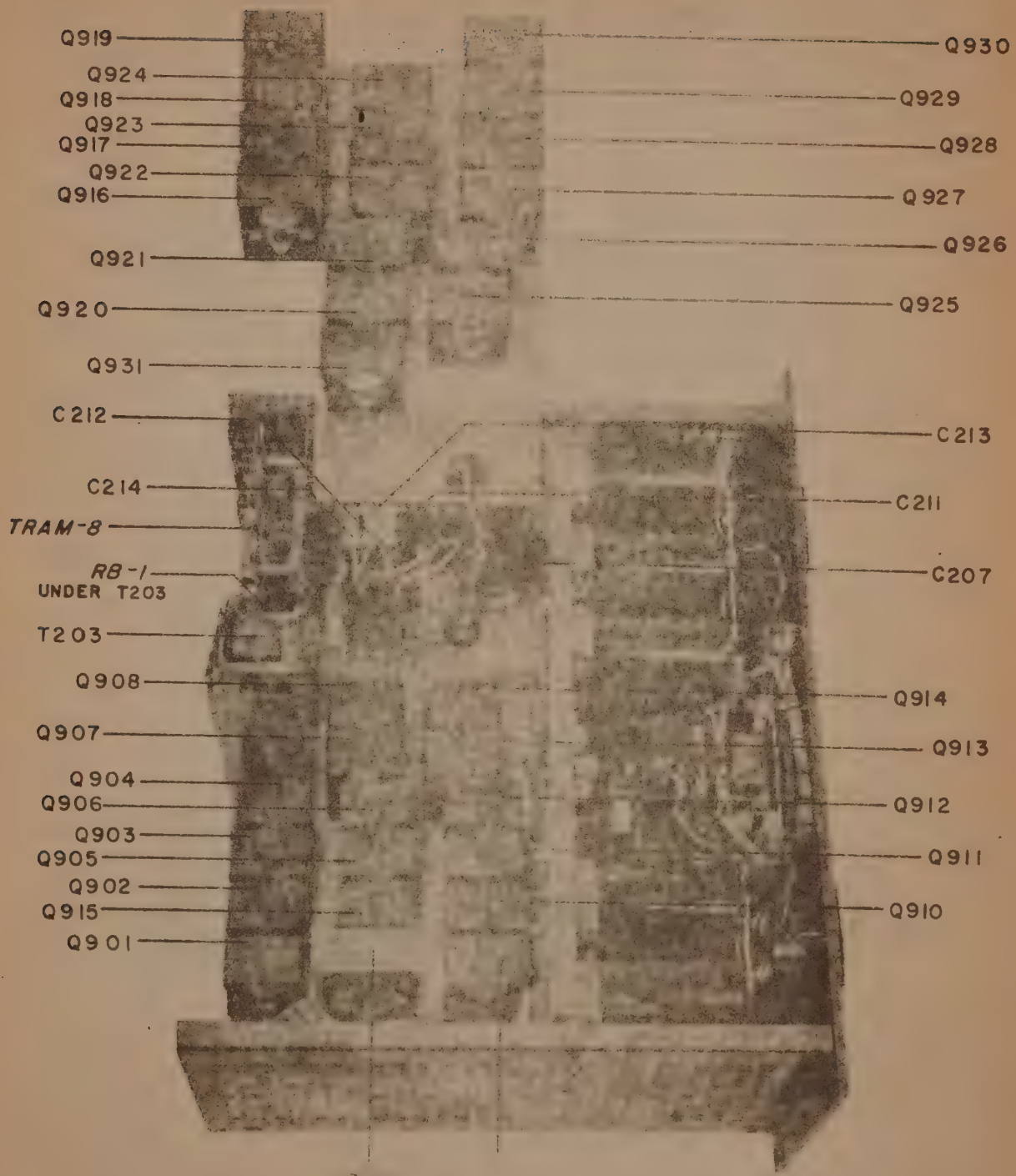
**See Field Replacement Page.

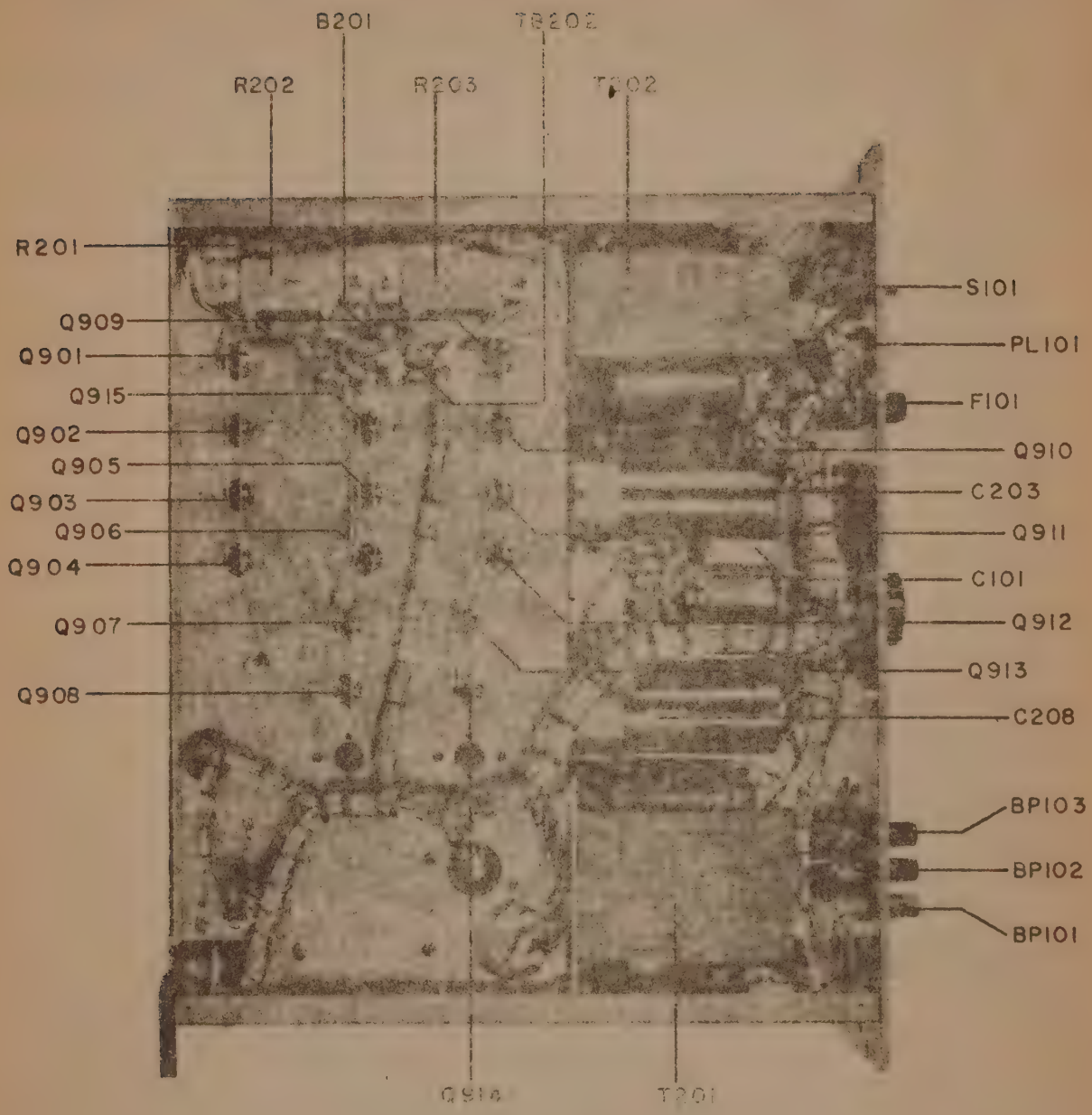
REPLACEMENT PARTS MAY BE ORDERED FROM KEPCO, INC. ORDERS SHOULD INCLUDE KEPCO PART NUMBER AND DESCRIPTION

PLEASE NOTE: THE MANUFACTURER'S NAME AND PART NUMBER LISTED FOR EACH ITEM ON REPLACEMENT PARTS LISTS REFLECTS AT LEAST ONE SOURCE FOR THAT ITEM AND IS LISTED SOLELY FOR THE CONVENIENCE OF KEPCO EQUIPMENT OWNERS IN OBTAINING REPLACEMENT PARTS LOCALLY. WE RESERVE THE RIGHT TO USE EQUIVALENT ITEMS FROM ALTERNATE SOURCES. KEPCO, INC.

Schematic Part No.	Kepco Part No.	Description	Specifications	Mfr.	Mfr's. No.
		Capacitors:			
C1	117-0105	Electrolytic, Pigtail Type	25 µf 25 v +100, -10%	Industrial Cond.	1B1063
C2	117-0129	Mylar	2 µf 200 v 10%	Hopkins Eng.	2P2MK
C3	117-0128	Mylar	0.4 µf 200 v 10%	Hopkins Eng.	P42MK
C4	117-0087	Ceramic	0.1 µf 500 v + 80, -20%	Sprague	41C92
Q1	119-0016	Transistor, PNP		Delco	119-0016
Q2, 3, 4, 5, 6, 8, 12, 11	119-0022	Transistor, PNP		Tung-Sol	2N382
Q7	119-0007	Transistor, NPN		Gen. Transistor	2N35
Q9, 10	119-0024	Transistor, NPN		Gen. Transistor	GT1092
		Resistors:			
R1	115-0439	Fixed, Molded	3.3 K Ω 1/2 w 10%	Allen-Bradley	EB3321
R2	115-0466	Fixed, Molded	2.2 K Ω 1/2 w 10%	Allen-Bradley	EB2221
R3, 4, 11	115-0459	Fixed, Power, Axial	500 Ω 3 w 5%	Ward Leonard	3X500
R5, 15, 22	115-0467	Fixed, Molded	4.7 K Ω 1/2 w 10%	Allen-Bradley	EB4721
R6, 7, 10	115-0469	Fixed, Power, Axial	2.5 K Ω 3 w 5%	Ward Leonard	3X2500
R8	115-0460	Fixed, Power, Axial	10 K Ω 3 w 5%	Sprague	151E-10K
R9	115-0473	Fixed, Molded	1.8 K Ω 1/2 w 10%	Allen-Bradley	EB1821
R12	115-0736	Fixed, Precision	1.8 K Ω 1/2 w 1%	Dale	WS-1/2
R13, 14	115-0471	Fixed, Power, Axial	100 Ω 3 w 5%	Ward Leonard	3X100
R16	115-0371	Fixed, Molded	220 Ω 1/2 w 10%	Allen-Bradley	EB2211
R17	115-0502	Fixed, Molded	10 Ω 1/2 w 10%	Allen-Bradley	EB1001
R18	115-0547	Fixed, Molded	1 K Ω 1/2 w 10%	Allen-Bradley	EB1021
R19	115-0782	Fixed, Molded	1.6 K Ω 1/2 w 5%	Allen-Bradley	EB1625
R20	115-0560	Fixed, Molded	2.7 K Ω 1/2 w 10%	Allen-Bradley	EB2721

Schematic Part No.	Kepco Part No.	Description	Specifications	Mfr.	Mfr's. No.
		Resistors:			
R21	115-0783	Fixed, Molded	300 Ω 1/2 w 5%	Allen-Bradley	EB3015
R23	115-0718	Fixed, Molded	45 Ω 1/2 w 10%	Allen-Bradley	EB4501
R24	115-0474	Fixed, Molded	4.7 Ω 1/2 w 10%	Allen-Bradley	EB47G1
R25	115-0600	Variable, Composition	300 Ω 2 w 10%	Allen-Bradley	JA1L040S301UZ
R26	115-0803	Fixed, Power, Axial	200 Ω 3 w 5%	Ward Leonard	3X200
RD1	121-0001	Zener Diode		Hoffman	1N429

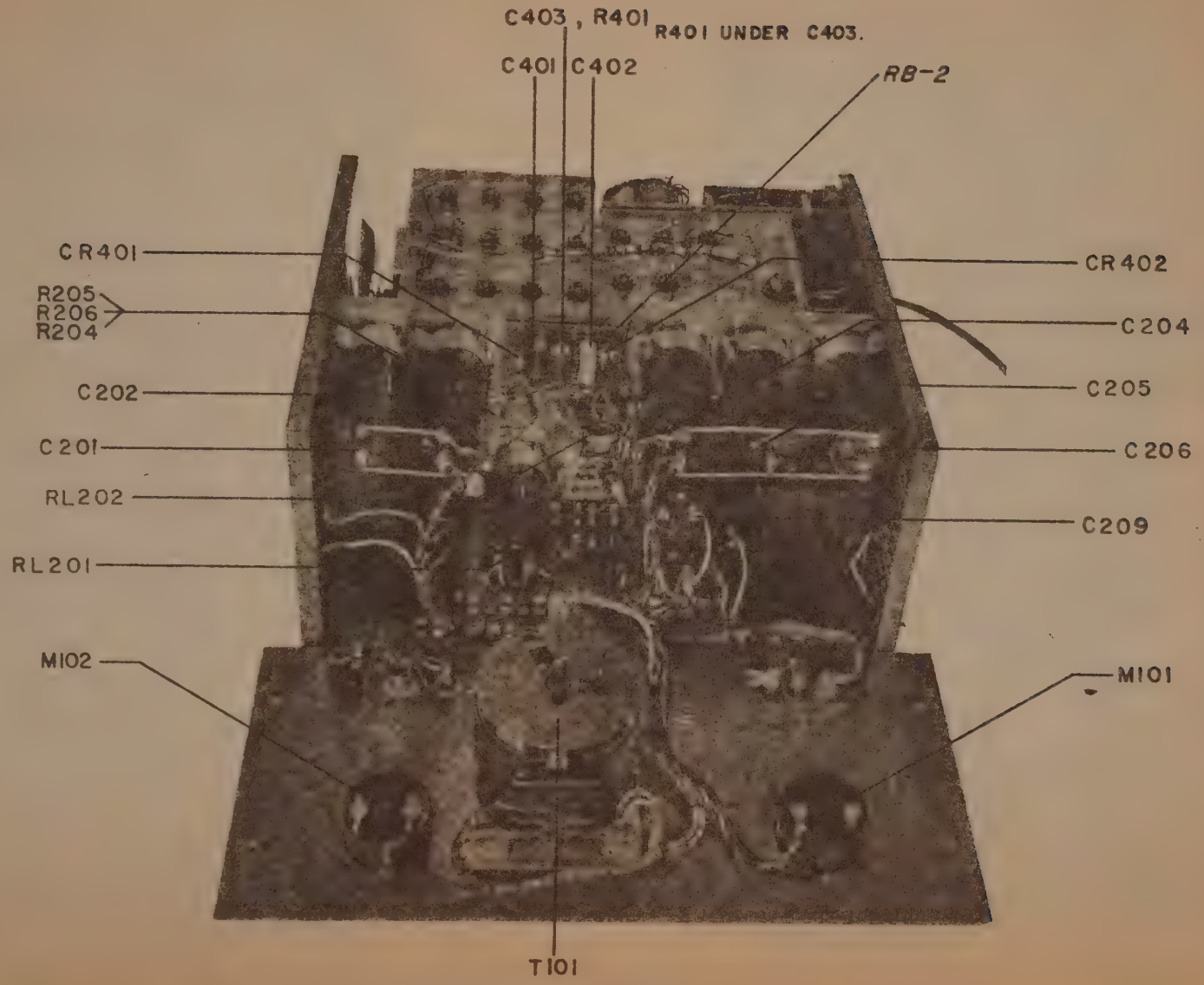

Q919
Q924
Q918
Q923
Q917
Q922
Q916
Q921
Q920
Q931
C212
C214
TRAM-8
RB-1
UNDER T203
T203
Q908
Q907
Q904
Q906
Q903
Q905
Q902
Q915
Q901
Q930
Q929
Q928
Q927
Q926
Q925
C213
C211
C207
Q914
Q913
Q912
Q911
Q910



SC-32-15A

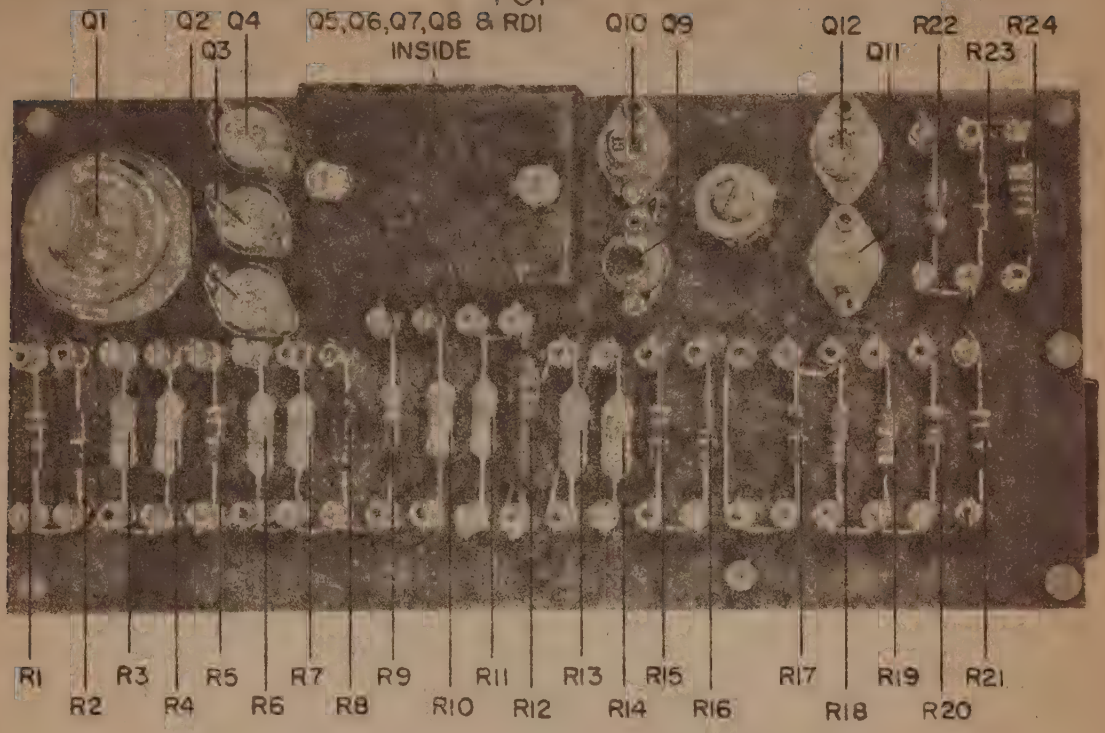
BOTTOM

SC-32-15A
INTERIOR



TRAM 8

TOP



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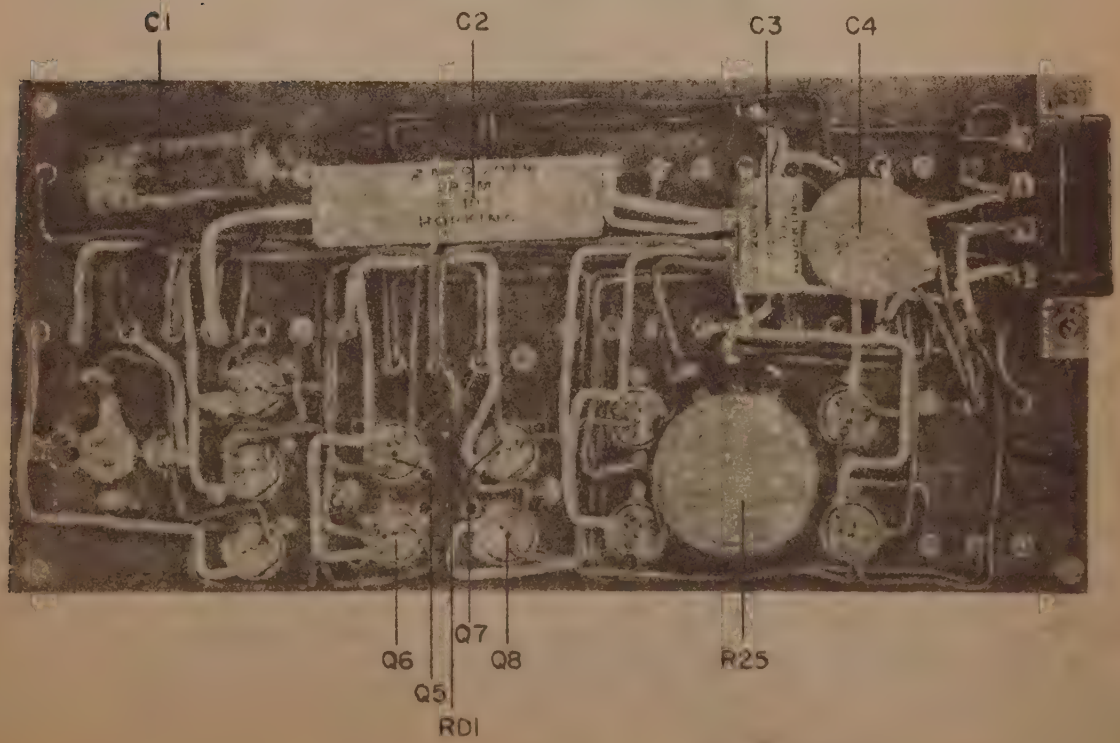
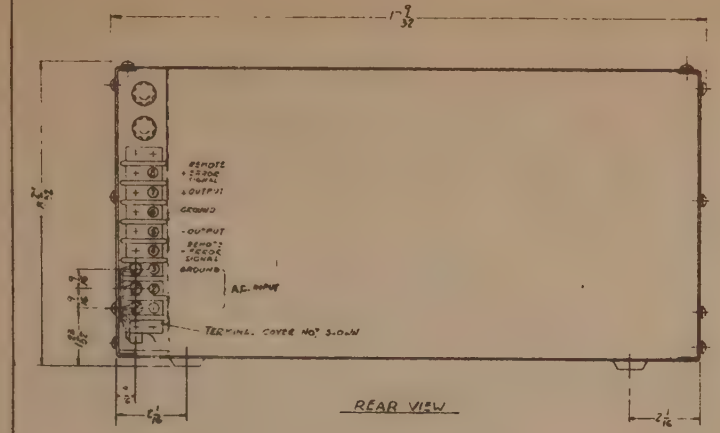
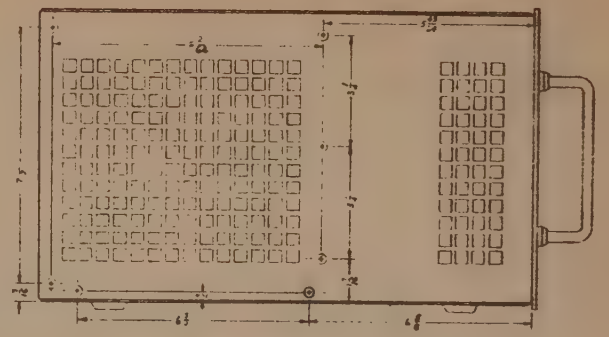
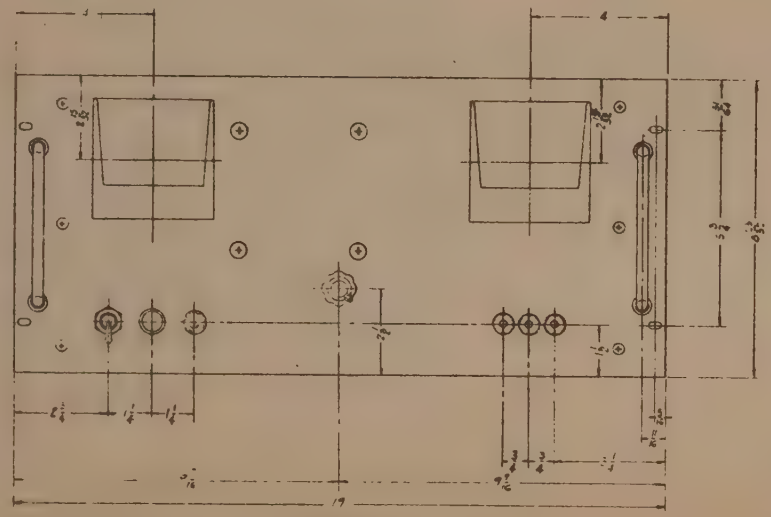




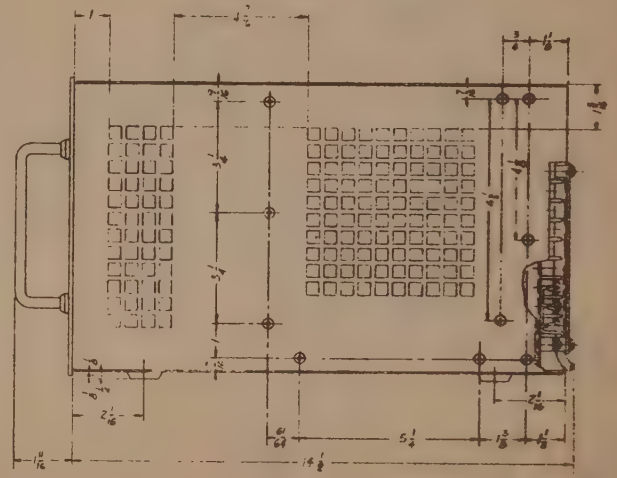
REAR VIEW



LEFT SIDE VIEW



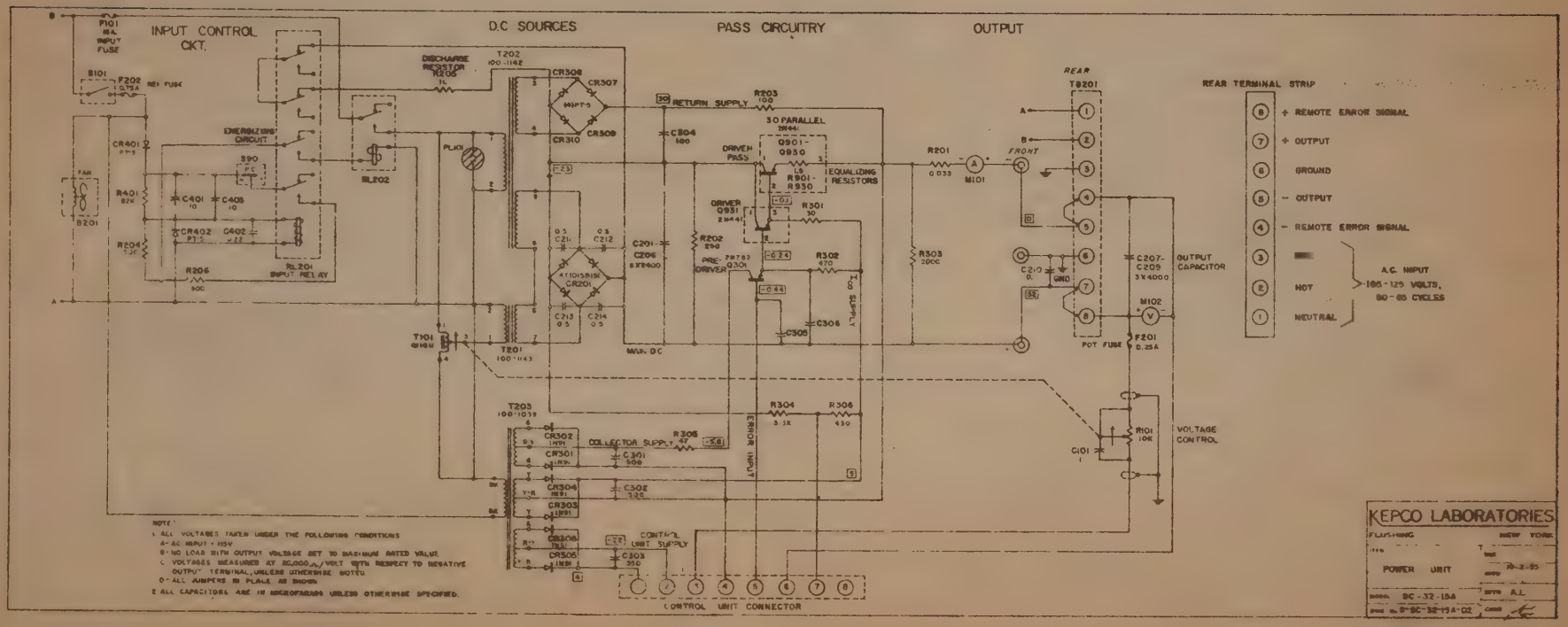
FRONT VIEW

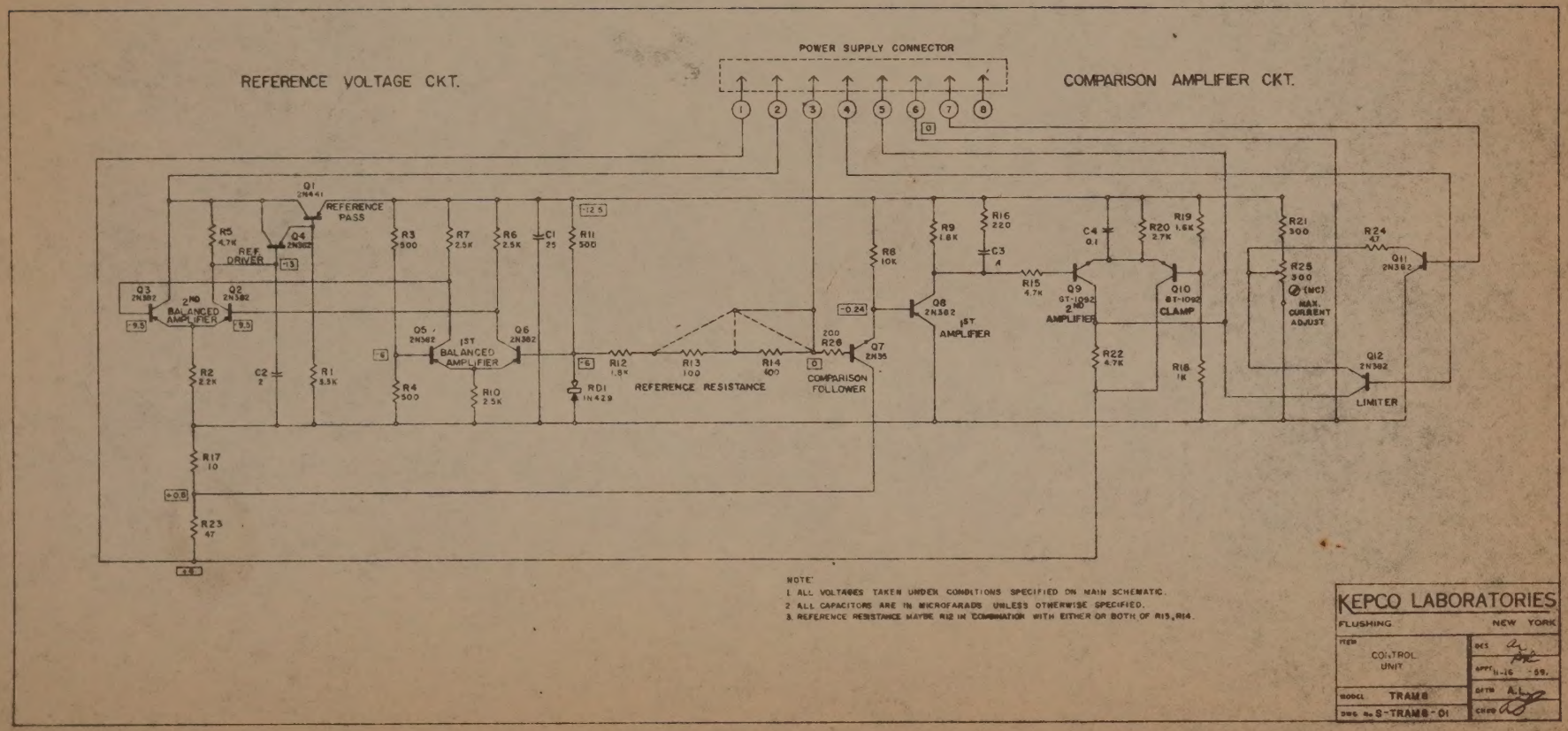


RIGHT SIDE VIEW

THIS DWG. USED ON MDL'S
SC-8E-10A
SC-300-1
SC-60-5
SC-3E-13A

KEPCO LABORATORIES		
FLUSHING	NEW YORK	
TITLE: OUTLINE DRAWING	DES.	CHKD: JHB
	APPD: X	SCALE
	DATE: A.C.S.	DATE: 4-9-59
MODEL: SC 8 3/4 SERIES	FINISH	DWG. NO.
DWG NO: CN00594	KEPCO NO.	


INPUT CONTROL CKT.
D.C SOURCES
PASS CIRCUITRY
OUTPUT
F101 15A. INPUT FUSE
S101
F202 1.0 15A
CR401
ENERGIZING CIRCUIT
S201
R401 82K
R204 5.1K
C401 10
C408 10
CR402
C402
R206 50C
RL201 INPUT RELAY
RL202
T202 100-1142
DISCHARGE RESISTOR R205 1K
CR308
CR307
CR310
CR309
BRIDGES
P101
T201 100-1143
T101 6W6U
C201-C206 6X2400
C213 0.5
C214 0.5
C211 0.5
C212 0.5
CR201 4110158151
MAIN D.C
RETURN SUPPLY
R203 100
C304 100
30 PARALLEL 2N441
DRIVEN PASS
Q901-Q930
R901-R930 EQUALIZING RESISTORS
DRIVER Q931 2N441
R301 30
PRE-DRIVER 2N782 Q301
R202 250
R302 470
C305
C306
T.O.O. SUPPLY
T203 100-1039
CR302 1N91
CR301 1N91
CR304 1N91
CR303 1N91
CR305 1N91
CR306 1N91
COLLECTOR SUPPLY
R305 47
C301 500
C302 320
C303 350
CONTROL UNIT SUPPLY
ERROR INPUT
R304 3.3K
R306 430
CONTROL UNIT CONNECTOR
R201 0.033
M101
REAR
FRONT
T8201
POT FUSE
F201 0.25A
C210 0.
GND
C207-C209 3X4000
OUTPUT CAPACITOR
R303 200C
M102
R101 10K
C101
VOLTAGE CONTROL
REAR TERMINAL STRIP
8 + REMOTE ERROR SIGNAL
7 + OUTPUT
6 GROUND
5 - OUTPUT
4 - REMOTE ERROR SIGNAL
3
2 HOT
1 NEUTRAL
A.C. INPUT 105-125 VOLTS, 60-65 CYCLES
NOTE:
1. ALL VOLTAGES TAKEN UNDER THE FOLLOWING CONDITIONS
A- AC INPUT - 115V
B- NO LOAD WITH OUTPUT VOLTAGE SET TO MAXIMUM RATED VALUE
C VOLTAGES MEASURED AT 20,000 Ω/VOLT WITH RESPECT TO NEGATIVE OUTPUT TERMINAL, UNLESS OTHERWISE NOTED
D- ALL JUMPERS AS PLACE AS SHOWN
2. ALL CAPACITORS ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
KEPCO LABORATORIES
FLUSHING NEW YORK
POWER UNIT
BC-32-15A
B-BC-32-15A-C2
A.L.



NOTE:
1. ALL VOLTAGES TAKEN UNDER CONDITIONS SPECIFIED ON MAIN SCHEMATIC.
2. ALL CAPACITORS ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
3. REFERENCE RESISTANCE MAYBE R12 IN COMBINATION WITH EITHER OR BOTH OF R13, R14.

KEPCO LABORATORIES	
FLUSHING	NEW YORK
ITEM: CONTROL UNIT	DES
	APPT 11-16-59
MODEL: TRAM6	DFTM A.L.
DWG. No. S-TRAM6-01	CHKD

KEPCO®

KEPCO, INC. • 131-38 SANFORD AVENUE • FLUSHING, N.Y. 11352 • (212) 461-7000 • TWX #710-582-2631 • Cable: KEPCOPOWER NEWYORK

#146-0045